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Effect of water saturation on the fragmentation threshold and tensile strength of rocks in volcanic environments

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Water plays an important role in the scheme of volcanism. Intrinsically it influences magma generation as well as its rheological properties (for instance viscosity) and the initiation of bubble nucleation, but also extrinsically, meteoric water or groundwater is the driving force to phreatic explosions which often are precursory to volcanic eruptions. Therefore, it is of great interest to investigate the influence of water on rock failure. Previous studies showed that even small amounts of water have a weakening effect on rock strength. For this study we chose two different rock types, resembling host rocks and volcanic rocks (e.g. old conduit filling). As volcanic rock, a dacite from Mount Unzen (Japan) was selected, and as host rock, a volcaniclastic sandstone from Northern Eldorado Mountain (Nevada, USA) was selected.

Two different experimental setups are used in this study. The first setup facilitates the failure of rock specimens by rapid decompression using a shock-tube apparatus. Therein a rock samples is slowly pressurized with argon gas up to a maximum pressure of 50 MPa and then rapidly decompressed to atmospheric conditions; the acting decompression rates in this facility are in the order of 10 GPa/s and higher. All of these experiments were carried out at room temperature and with varying degrees of water saturation. The resulting dataset allows us to investigate the correlation between the degree of water saturation and the fragmentation threshold, which is the minimum applied pressure required to fully fragment a sample.

Secondly, Brazilian tests were carried out to investigate tensile strengths of both sample types, with different degree of water saturation. 40mm x 40mm discs are mounted along length in a brazil jig, subsequently loaded in a uniaxial press at a rate of 200N/s. So far we used solid samples (not notched) for the tests yielding indirect tensile strength values.

For both sample sets we observe a reduction in tensile strength and fragmentation threshold with increase water saturation. The coupling of tensile strengths and decompression thresholds in the presence of water aims to provide a better view on the occurrence of phreatic explosions and thus mitigate related hazards.